Examining the Price of Insurance in the Agricultural Supply Chain

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ABSTRACT

The agricultural supply chain is vulnerable to adverse business conditions, which can be attributed to production uncertainty and price volatility. Risk exists in all agricultural management decisions, primarily due to uncertainty. Price instability reduces investment in the agricultural supply chain. This study explores risk management by introducing price insurance, which may increase investment in the agricultural food supply chain. The statistical population of this research is the Agricultural Bank Insurance Fund of Fars Province. The orientation of this research is developmental and applied. The philosophy of the research is positivist and rigorous, and the research approach is comparative. The strategy in this research is also survey-based. A model is introduced that shows how price-based insurance products can reduce investment risk and how lower investment can have a similar impact to higher investment. This study shows that introducing insurance in the agricultural supply chain can encourage small and medium-sized companies to invest in agriculture and help policymakers better understand the social benefits of food chain risk management and make more effective decisions about subsidy policies with better private sector participation.

Keywords:

Agricultural supply chain, price insurance, investment.

1. Introduction

The production and distribution of the agricultural food supply chain are major global challenges that require innovative solutions. The demand for food has increased significantly, prompting food industry stakeholders to innovate beyond organizational boundaries to develop agricultural food supply chains. The agricultural supply chain is vulnerable to adverse business conditions (Eurostat, 2014), which can be attributed to production uncertainties such as weather conditions, natural disasters, pests, diseases, and market price volatility, which can negatively impact farmers' income stability (Alizamir et al., 2019). To address the complexities arising from globalization and technological advancements, the entire supply chain, from farmers to consumers, must be considered, involving all key stakeholders, including investors, institutions, and risk-reducing policies. Risk exists in all agricultural management decisions, primarily due to uncertainty (Geman et al., 2014; Li et al., 2014). Globalization and supply chain expansion increase complexity, leading each supply chain link to pursue its own goals, which may disrupt the supply chain due to conflicting objectives. Research has shown that supply chain management, alongside investment risk management, can improve company flexibility, financial performance, and competitive advantage (Assa et al., 2021). A major challenge in the agricultural food supply chain is encouraging continued new investment. This is because agricultural products have a long process that requires continuous investment. Research on investment in agricultural businesses shows significant impacts on investment decisions (Heikkinen and Pietola, 2009). Price instability reduces investment in the supply chain (Enjolras and Kast, 2012). The agricultural industry supply chain must respond to increased demand and supply gaps, as well as price fluctuations (Sharma et al., 2018; Patidar et al., 2018). Due to the low efficiency and high cost of agricultural product circulation, monitoring agricultural product quality is challenging. Currently, the agricultural product supply chain has many shortcomings, including low efficiency and high waste. Direct interaction between supply chain links can save costs and resources and ultimately control quality (Sharma et al., 2020). Due to globalization, income risk has become as important as production risk. Globalization increases price volatility, which increases income risk. Unstable prices are one of the biggest problems in the food supply chain and have also attracted political attention (Defra, 2019). A key point in risk management is that in environments such as food, where there is high uncertainty due to price volatility, involving third parties like insurance companies to insure products can reduce risk. Insurance agents can facilitate farmers' investment and increase their satisfaction by choosing appropriate pricing strategies. Increasing and growing satisfaction and loyalty of farmers ensures future income for them. Insurance companies and agents are no exception to this rule, and customer satisfaction is a key factor in their survival. Therefore, given the extraordinary importance of customers (farmers) in the insurance industry and the number and nature of service providers to policyholders in the country's market, the relationship between pricing and investment, as well as policyholders' satisfaction with fair prices, is of great importance. This approach, which has gained more importance in national and regional policies, is reflected (Alizamir et al., 2019).

2. Literature Review

The agricultural supply chain may be influenced by the conflicting interests and objectives of suppliers and investors (players). Additionally, the demands received may be affected by the conflicting objectives of the players, making it essential to pay attention to the interactions between suppliers (farmers) and investors, such as competitive activities or strategic alliances. Given the conflicting objectives between suppliers and investors and other players, a suitable model for investment in uncertain environments is of great interest to researchers. Additionally, examinations in the agricultural industry have shown that this industry faces problems such as lack of effective support, price fluctuations, absence of a comprehensive investment model, and the like. Sometimes in organizations, due to lack of recognition of important competitive factors between companies, as well as lack of strategic positions and correct scenarios, investment will decrease. Given that agriculture does not seem like a very attractive business for investors without sustainable income, creating income stability through the introduction of financial approaches for farmers is a challenge (Assa et al., 2021).

Insurance is a financial risk mechanism that is part of a comprehensive risk management strategy and also plays an important role in mitigating the effects of disasters (Alam et al., 2020). Studies on price fluctuations not only show that they affect the supply chain but also that the benefits of one player (for example, farmers) can harm others (for example, food supply services) and vice versa. This issue is more important for non-cooperative companies such as farms. Farms are usually very small companies that have a very limited share in their markets, making them vulnerable to uncertainty (Defra, 2019). Factors such as large deposits, technical trading skills, transaction costs, and regulations arising from price fluctuations make access to markets almost impossible for small and medium-sized companies (Akhtar et al., 2019). Due to the sensitive and decisive role of insurance companies in financial markets, especially in the capital market, and because the main subject of this research is examining the role of insurance companies in the capital market, insurance companies receive amounts under the title of insurance premium and commit to paying certain potential damages in the future. Since the occurrence of damages is firstly probable and secondly related to the future, there is a significant time lag between receiving the insurance premium and paying the damages in case of accidents. This time lag actually provides the possibility of investing the accumulated funds. Generally, the activity of insurance companies can be divided into life insurance and non-life insurance branches. Due to the longer gap between receiving the insurance premium and paying the damages in life insurance branches, the received funds from these branches provide the possibility of more and long-term investment. Therefore, a very high share, even more than 50 percent, of the activity of insurance companies in developed countries that have a competitive and efficient insurance market is related to life branches. This leads to the active and extensive participation of insurance companies in the capital market and providing funds for investment. Life insurance, especially life insurance, not only provides peace of mind for policyholders but also leads to the formation of capital. Since the diversity and breadth of insurance activities can cover all economic sectors and the entire population of the country and lead to the accumulation of large funds, it can, in addition to providing security, become an important channel for accumulating resources and directing them towards productive economic activities. The point that should be noted in this regard is that the role of the insurance industry in equipping savings resources as a financial institution should be given special attention during difficult economic periods and severe inflation, the power to equip savings resources and other financial tools and institutions is greatly reduced, and the savings resulting from insurance activities become the only channel for people's savings. Studies show that there are two types of agricultural insurance for managing two types of production and price risks, including crop insurance and income insurance. While crop insurance focuses on crop damage and low yield, income insurance guarantees a minimum income for farmers and producers (Assa et al., 2020).

Assa et al. (2021) established a theoretical framework for introducing an insurance product for price indices with the aim of stabilizing farmers' income and encouraging investment in the agricultural industry and used insurance to examine how to influence and improve investment.

The four main players forming the chain are as follows: supplier (farmers), retailer, insurance company, and investor. The role of the insurance company is to issue an insurance contract for the premium, and the role of the retailer is to decide on demand. On the other hand, an investor will be looking for risk decisions between investing in the agricultural industry or the profit from capital at a specified interest rate.

Bannor et al. (2023) examined risk management techniques and the willingness to insure poultry farms by poultry farmers in Ghana. For analysis, random parameter Logit (RPL) and conditional Logit (CL) models were used. Key risks identified included disease, marketing, and financial risks. Primary insurance features included the insurance period, risk covered, type of participation, price (amount paid per year), and amount covered. The premium was $5.96 per month, which farmers were willing to pay to insure their farms. The results also showed that family size, price, and type of participation had a negative impact on agricultural insurance participation. In contrast, education, farming experience, insurance period, and risk covered had a positive impact.

Zhang et al. (2023) reached the conclusion in their research that severe weather events could pose a significant threat to the agricultural economy and that agricultural insurance acts as an effective tool for risk reduction. They, motivated by the agricultural policies of the Chinese government, developed a theoretical model to analyze full-cost insurance and income insurance and how governments should design insurance subsidies. The results showed that optimal government insurance subsidies under various insurance schemes are closely related to the uncertainty and efficiency of production performance under severe weather risk. When the efficiency of farmers' production is low regardless of the subsidy level, the supply of agricultural products can be guaranteed under full-cost insurance. However, when production efficiency is high, a lower subsidy level should be set under full-cost insurance, while a higher subsidy level is required under income insurance. Furthermore, the optimal levels of government insurance subsidies under various insurance schemes may not always align with the interests of farmers. The government can maximize social welfare by ensuring the sustainable supply of agricultural products.

Ai et al. (2023) conducted an article based on data from agricultural insurance and agricultural credit in 31 provinces and cities in China, reaching an empirical analysis of the impact of poverty reduction on the relationship between agricultural insurance and agricultural credit and the regional differences in China using the coupling coordination model and static panel model. The results showed that the level of development of agricultural insurance and agricultural credit in China is low, and the level of development of agricultural credit is higher than agricultural insurance. There is a harmonious development relationship between agricultural insurance and agricultural credit in China, and the level of linkage and coordination between the two is continuously improving. The impact of poverty reduction on the relationship between agricultural insurance and agricultural credit and regional differences in China is significant. This effect is more noticeable in southern China, northern China, northwest, and northeast China compared to other regions.

This study attempts to introduce a new risk management approach to protect the unstable income of supply chains in the agricultural industry. The aim of this research is to examine the impact of product prices on investment in the agricultural industry. This study has a significant contribution to the management of the agricultural food supply chain by offering to protect the unstable income of small and medium-sized companies. Additionally, this research aims to encourage the insurance industry to introduce its products to ensure the income of supply chain members and thereby encourage an increase in investment rates.

Given that there is a conflict of interest between the goals of supply chain members and each member of the supply chain aims to achieve the best results and their own goals, it is necessary to use game theory to handle the interaction between supply chain members and address the conflicting goals among them. The difference between this research and previous studies on non-cooperative supply chain goals lies in the use of game theory modeling in a competitive uncertain environment (considering the conflicting goals among supply chain members).

3. Research Methodology

This research is developmental and applied in nature and the research philosophy is positivist and hard. The research approach in this study is comparative.

The strategy in this research is survey-based. The research time horizon can be considered multi-sectional. The method of data collection in this research has been field-based.

In this research, structural equations and factor analysis methods have been used. The statistical population of this research includes insurance companies in Fars Province. Both library and field methods have been used to collect data. For the theoretical literature, the library method was used, and for collecting other necessary information, field methods were employed. In the library studies section, books and articles related to the topic were used, and in the field methods section, organizational documents and records were used to collect data. Additionally, the Lawshe method was used to determine validity.

As shown in Figure 1, four main players have been identified to form the chain: a supplier, a retailer, an insurance company, and an investor. The role of the insurance company is to issue an insurance policy for the insurance premium. On the other hand, an investor is deciding between investing in agricultural trade or benefiting from capital profit based on a fixed interest rate r.

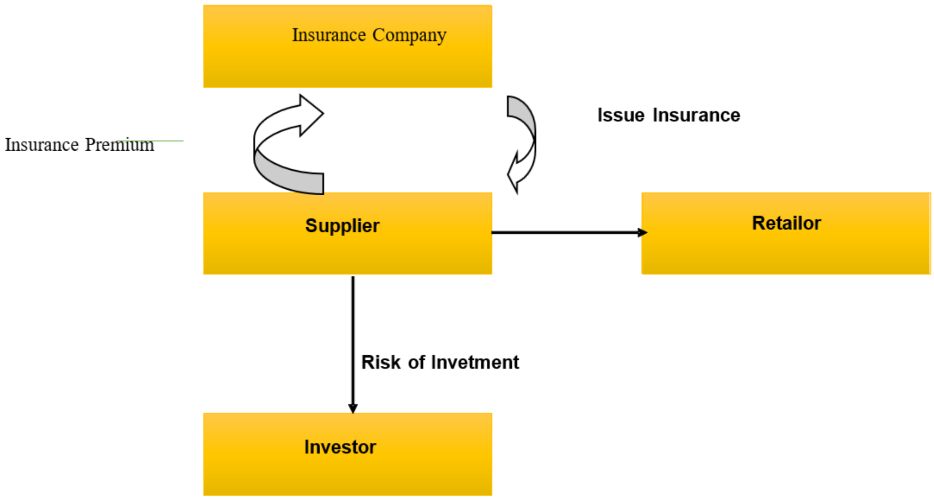

Figure 1.Investment and agricultural supply chain (Assa et al., 2021)

Based on economic theories, primarily referring to Schultz's (1971) effects, investment benefits a farming business by reducing costs, which can result from investing in new technologies or training agricultural human resources. We primarily consider the four players, as the investment is decided by the farmer, we have considered a single entity (supplier) that represents both the farmer and the investor. On the other hand, the main role of the insurance company here is to issue an insurance policy and collect the insurance premium. This means that the insurance company will not enter the optimal decision-making problem, as it manages its risk by adopting a different integration strategy, which is not the subject of this article. In fact, our set essentially considers two decision-makers, a farmer who decides on investment and insurance, and a retailer who decides on quantity (demand). First, we introduce the model symbols as follows:

q: demand quantity (determinant).
i: investment amount.
w: transfer price paid by the retailer to the supplier (random amount).
y: insurance contracts (insured loss).
p(q): price per unit of final production based on demand (q).
C_S: supplier's unit production cost.
C_R: retailer's unit production cost.
QS: supplier's risk index.
π: insurance premium function.

The supplier's profit and the retailer's profit are calculated as follows:

$$P_S = q(w - C_S(i) - (1 + r)i)$$
$$P_R = q(p(q) - (w + C_R))$$

The statistical population in the quantitative section includes all professors, experts, specialists, officials, and managers of insurance companies in Fars Province. Due to the uncertain number of the statistical population and considering the Cochran sample size in uncertain conditions, 384 individuals were considered as the statistical sample. The sampling method used was convenience sampling. After drafting the questionnaire using the Likert scale from 1 to 5, it was made available to the statistical sample through various methods such as email, in-person visits, fax, etc.

Validity and Reliability of Research Tools in the Quantitative Phase:

After preparing the preliminary questionnaire, it was provided to 10 experts in management and research methods. After necessary editorial revisions, its face and content validity were confirmed by the mentioned experts.

Content Validity

In this research, a questionnaire consisting of 23 questions in the first stage was confirmed for face and content validity using the Lawshe CVR form. The results in Table 1 show the content validity of the questionnaire model for insurance prices to encourage investment in the agricultural supply chain. According to the formula CVR = (NE - N/2) / (N/2) and in accordance with the Lawshe table, considering that the number of experts was 10, the acceptable level for content validity according to Lawshe for each question was set at 0.66. According to the above value, the content validity of all questions was confirmed.

NE = Number of necessary responses

N = Number of experts

CVR = Content validity index

Table 1. Content Validity Results of the Questionnaire

Content Validity Value	Questions	Content Validity Value	Questions
1.00	12	0.83	1
0.83	13	0.66	2
1.00	14	1.00	3
0.83	15	1.00	4
1.00	16	0.83	5
0.66	17	0.66	6
1.00	18	0.66	7
0.66	19	1.00	8
0.83	20	0.83	9
0.83	21	0.83	10
1.00	22	1.00	11
0.83	23	-----	-----

These results indicate that the questionnaire has an appropriate content validity, and its questions are suitable and necessary for the research topic (encouraging investment in the agricultural supply chain through insurance pricing).

Structural Validity Using Structural Equations Approach

To determine the adequacy of the sample for factor analysis, the Kaiser-Meyer-Olkin test was used. Additionally, Bartlett's test was used to assess the correlation between the items.

Table 2. Kaiser-Meyer-Olkin and Bartlett's Test

Test	Value
Kaiser-Meyer-Olkin	0.721
Bartlett's Test	Approximate Chi-Square
Degrees of Freedom	254
Significance Level	0.001

As shown in Table 2, the Kaiser-Meyer-Olkin index is 0.721, indicating that the sample size is highly adequate. The results of Bartlett's test, with a significance level of 0.001 ($P < 0.01$), show that the data have the ability to form factors. Therefore, it is concluded that factor analysis is appropriate for the data in this research.

Reliability

The questionnaire was piloted with 40 individuals from the statistical population. After completing the questionnaires, the reliability of the tool was evaluated using Cronbach's alpha method, which resulted in a value of $\alpha = 0.94$, indicating very high reliability of the tool used. The reliability of each dimension of the questionnaire was calculated separately, and the results are presented in Table 3.

Table 3. Reliability of Different Dimensions of the Questionnaire

No.	Factor	Reliability
1	Insurance Companies (Premium and Insurance Contract)	0.90
2	Supplier	0.95
3	Retailer	0.92
4	Investor	0.92

These high reliability values indicate that the questionnaire is consistent and reliable in measuring the intended constructs across different dimensions.

As observed in Table 4, the results of the exploratory factor analysis, conducted using the principal component method with Varimax rotation, indicate that a four-factor structure is an appropriate method for describing the variables related to the model for pricing insurance products to encourage investment in the agricultural supply chain. These four factors together explain 68.36% of the scale variance.

Table 4. Results of the Exploratory Factor Analysis Test

	Factor Loadings			
Items	Insurance Companies	Supplier	Retailer	Investor
Q1	0.78			
Q2	0.70			
Q3	0.63			
Q4	0.55			
Q5	0.59			
Q6		74/0		
Q7		68/0		

	Factor Loadings			
Items	**Insurance Companies**	**Supplier**	**Retailer**	**Investor**
Q8		54/0		
Q9		52/0		
Q10		50/0		
Q11			74/0	
Q12			76/0	
Q13			66/0	
Q14			62/0	
Q15			51/0	
Q16				51/0
Q17				75/0
Q18				70/0
Q19				66/0
Q20				60/0
Q21				72/0
Q22				67/0
Q23				64/0
Eigen value	3.59	3.10	2.78	5.12
Total Variance	19.11	17.10	16.14	1.12

The eigenvalue values indicate how much each factor explains the variance of the scale. For example, the "Investor" factor with an eigenvalue of 5.12 has the largest share in explaining the variance of the scale. Overall, these four factors together explain 68.36% of the scale variance, indicating that the four-factor structure is suitable for the model of pricing insurance products to encourage investment in the agricultural supply chain.

As seen in Table 5, the results of the confirmatory factor analysis test regarding the components of the model for pricing insurance products to encourage investment in the agricultural supply chain show that the research questions have factor loadings, and the next step is to perform confirmatory factor analysis.

The goal of factor analysis is to confirm the proposed factor structure and examine the relationships between the constructs and the questions. This stage helps us ensure that the proposed model for pricing insurance products to encourage investment in the agricultural supply chain is appropriate and reasonable.

As observed in Table 6, the evaluation indices of the overall structural equation model indicate that the proposed model formulated by the research data is supported, meaning the data fit the model well, and all indices suggest the acceptability of the structural equation model.

Overall, the fit indices suggest that the structural equation model is a good fit for the data, supporting the proposed model formulated by the research data. This means that the data align well with the model, and the model is acceptable for explaining the relationships between the constructs and the questions in the context of pricing insurance products to encourage investment in the agricultural supply chain.

Table 5. Results of the Confirmatory Factor Analysis Test

	Factor Loadings			
Items	**Insurance Companies**	**Supplier**	**Retailer**	**Investor**
Q1	.64			
Q2	.60			
Q3	.59			
Q4	.53			
Q5	.50			
Q6		.62		
Q7		.60		
Q8		.58		
Q9		.54		
Q10		.51		
Q11			.70	
Q12			.68	
Q13			.62	
Q14			.58	
Q15			.57	
Q16				.50
Q17				.62
Q18				.53
Q19				.65
Q20				.66
Q21				.60
Q22				.58
Q23				.59

Table 6. Fit Indices of the Final Model

Chi-square (X2)	df	X2/df	RMSEA	CFI	GFI	AGFI	NFI
198.82	178	1.1	0.084	0.91	0.92	0.90	0.90

As seen in Table 7, the model results show that there is a correlation between the components of the model for pricing insurance products to encourage investment in the agricultural supply chain, with the highest correlation being between the supplier and the investor at 0.801 and the lowest correlation being between the investor and the retailer at 0.538.

Table 7. Relationship Between Model Variables for Pricing Insurance Products to Encourage Investment in the Agricultural Supply Chain

Variables			R
Insurance Companies	↔	**Supplier**	0.728
		Retailer	0.787
		Investor	0.711
Supplier	↔	**Retailer**	0.665
		Investor	0.801
Retailer	↔	**Investor**	0.538

These correlations indicate that there are strong relationships between the various constructs of the model for pricing insurance products to encourage investment in the agricultural supply chain. The highest correlation is between the supplier and the investor at 0.801, and the lowest correlation is between the investor and the retailer at 0.538. These strong correlations show that these constructs significantly impact each other and can play an important role in designing and implementing insurance pricing strategies to encourage investment in the agricultural supply chain.

As observed in Table 8, the model results show that insurance companies (premium and insurance contract) affect the model for pricing insurance products to encourage investment in the agricultural supply chain with a value of 0.59; the supplier affects the model for pricing insurance products to encourage investment in the agricultural supply chain with a value of 0.70; the retailer affects the model for pricing insurance products to encourage investment in the agricultural supply chain with a value of 0.65; and the investor affects the model for pricing insurance products to encourage investment in the agricultural supply chain with a value of 0.55.

Overall, the results show that all hypotheses are accepted, indicating that each variable (insurance companies, supplier, retailer, and investor) significantly affects the model for pricing insurance products to encourage investment in the agricultural supply chain. The standard estimates (0.59, 0.70, 0.65, and 0.55) quantify the strength of these effects, with the supplier having the strongest influence followed by the retailer, insurance companies, and the investor. These findings highlight the importance of each stakeholder in the agricultural supply chain and their roles in shaping effective insurance pricing strategies to encourage investment.

Table 8. Direct Effects of Variables and Hypothesis Results

Hypotheses	Significance Level	Critical Ratio	Standard Error	Standard Estimate	Research Variables
Accepted	0.003	5.21	0.14	0.59	Insurance Companies (Premium and Insurance Contract) affect the model for pricing insurance products to encourage investment in the agricultural supply chain
Accepted	0.002	6.30	0.18	0.70	Supplier affects the model for pricing insurance products to encourage investment in the agricultural supply chain
Accepted	0.003	5.15	0.22	0.65	Retailer affects the model for pricing insurance products to encourage investment in the agricultural supply chain
Accepted	0.001	4.10	0.17	0.55	Investor affects the model for pricing insurance products to encourage investment in the agricultural supply chain

Table 9: Fit Indices of the Final Model

Index	Chi-square (X^2)	df	X^2/df	RSMEA	CFI	GFI	AGFI	NFL
Value	119.29	89	1.34	0.040	0.94	0.90	0.92	0.92

The results show that all fit indices are within the acceptable range, indicating that the proposed model is supported by the research data. In other words, the data fits the model well, and all indices suggest the acceptability of the structural equation model.

The problem for the supplier is to maximize their profit. However, since the supplier is risk-averse, they must also consider the impact of risk. Loss for the supplier occurs when prices fall below the production cost, i.e.:

$L(i) = (C_S(i) - w)$

Here, the supplier chooses a risk criterion that indicates their estimated risk (i.e., an estimate of how much damage they will incur). Thus, the supplier's objective is to maximize the following goal for q units of farm production:

$E(q(w-C_S(i)-(1+r)i)-QS(qL)$

If we consider the supplier's access to insurance, we can modify the objective function with an insurance contract y as follows:

$E(q(w-C_S(i)-(1+r)i)-\pi(qy)) -QS(qL)$

In this paper, we use a risk criterion QS to model the risk behavior of the farmer, while the insurance premium π is used to denote the insurance contract premium. To unify the definition of risk criteria and insurance premium risk, we define the risk map as follows:

Definition 1. A risk map ρ on a set of random variables is defined and can be represented as:

$\rho(y) = \int_0^1 \mathrm{VaR}_t(y)d\pi(t)$

where

VaRα(y)=inf{c∈R|α≤Fy(c)}

and :[0,1]→[0,1]π:[0,1]→[0,1] is a non-decreasing function such that (0)=0π(0)=0 and (1)=1π(1)=1.

Where

$\pi(t)$=1−αt−α

is used, the following value is used:

CVaRα(y)=1−α1∫α1VaRt(y)dt

While VaR only relates to a quantile (α percent), CVaR takes a weighted average of all risk values greater than VaR.

In this paper, we measure risk and insurance premium risk as follows:

QS(y)=∫01VaRt(y)dπS(t)

π(y)=∫01VaRt(y)d$\pi\pi$(t)

With the risk criterion and insurance premium risk defined, we can now study the risk coverage problem to minimize the farmer's loss. We consider contracts in the form y=k(L), where k is called the compensation function and g(c)=c−k(c) is defined as the remaining loss function. To avoid improper coverage, we define some conditions on the insurance contracts.

First, we assume that zero damage requires no compensation and no remaining loss, (0)=0k(0)=g(0)=0.

Second, we assume that compensation is consistent with increasing damage, meaning that greater damages require higher compensation. This assumption implies that k is a non-decreasing function.

Third, we assume that the insurance company, assuming no decrease in i, does not over-cover the damages, which can be justified as a larger risk cannot imply a smaller accumulated loss.

4. Results and Discussion

In this section, we consider two different approaches to find optimal solutions: the Total Profit (TP) approach and the Stackelberg game approach. The first approach views the problem from a social planner's perspective, while the second approach views it from an individual's perspective. According to economic theories, the social planner values the overall economic welfare. In our case, there are suppliers and retailers whose total profit can represent overall welfare. It is important to note that the sum of individual profits is meaningful here, as they are not just numbers indicating player preferences (like the utility function value), but values representing the monetary value of the business. Moreover, using risk criteria is consistent with this view, as the value of a risk criterion is as important as profit.

On the other hand, we may consider the individual's perspective, where they only care about maximizing their own profit, which is more aligned with game theory. However, it should be noted that in this game, the two players do not move simultaneously, as one can expect the other to move.

In our problem, the retailer makes the first move, and then the supplier follows. For this purpose, we have chosen the Stackelberg game approach, which is a common framework for studying such games. It can be said that introducing insurance always increases profit, as more options are available to decision-makers.

Total Relative Insurance Profit

The risk situation value V_N is where there is no insurance, and the risk situation value V_{IN} is where there is an insurance contract. Therefore, the demand and supply prices can be presented as follows:

Demand Price:

$V_{IN} = b^A + V_N$

Supply Price:

$V_{IN} - b^B = V_N$

Then we can introduce the total profit with the introduction of insurances as follows:

$V_N - V_{IN} = b^B = b^A$

The total relative profit (RTB) is written as:

$$\text{RTB} = 1 - \frac{V_N}{V_{IN}}$$

which is more fully introduced as:

$$\text{RTB} = 1 - \frac{q_N^*(p(q_N^*) - C_S(i_N^*) - C_R - (1+r)i_N^* - Q_S(L(i_N^*)))}{q_{IN}^*(p(q_{IN}^*) - C_S(i_{IN}^*) - C_R - (1+r)i_{IN}^* - Q_I(L(i_{IN}^*)))}$$

The relative insurance profit considering the amount (RB_q) is also considered as follows:

$$\frac{\min\{(1+r)i + Q_I(L(i)) + C_S(i)\}}{\min\{(1+r)i + Q_S(L(i)) + C_S(i)\}}$$

To align with financial literature, we have chosen the Log-Normal distribution for prices, inspired by the Black-Scholes model with no-arbitrage conditions. The no-arbitrage condition indicates that for a Log-Normal model (μ,σ), we should consider r=μ. The risk-free rate r is taken as 5% and 10% to represent the risk-free rate increase, i.e., r∈{0.05,0.1}.

The volatility σ is taken as 10% and 25% to represent the annual volatility of two risk regimes, i.e., ∈{0.1,0.25}σ∈{0.1,0.25}. We take =1CS =1 and =0CR=0. Changing CR does not change the results, however, CS can make a difference. The risk tolerance parameter for the two risk-averse features is chosen with ∈{0.9,0.95}α∈{0.9,0.95}. We have used two risk criteria VAR and CVAR and also considered the expected insurance premium function, i.e., π(X)=E(X).

Here, we further explain the cost function. We consider a non-increasing function and then try to perform a valid calibration. Let us consider the following function for 0δ>0:

$$C_S(i) = \frac{C_S}{(1+i)^\delta}$$

The parameter δ of this function apparently is a decreasing function which is also NC, i.e., 0CS <0 and CS>0.

Generally, a larger δ reduces the cost function more, and thus, a lower relative insurance profit can be expected. We have considered two main areas for investment: physical capital and human capital. By adopting a theoretical economic framework, the corporate farm is where profits are mainly defined under physical or human capital. Using a standard Cobb-Douglas production function, we can define production (P) as follows:

$P = AL^{\psi\ 1}K^{\psi\ 2}$

Here, A is the total factor productivity (usually indicating the effect of technology), L is human capital (usually as labor), and K is physical capital. The parameters ψ 1 and ψ 2 are numbers that indicate the output elasticity of human and physical capital, respectively.If we follow the reasoning in calibration, we can infer that if an individual decides to invest in human capital, the relative insurance profit will be lower. The reason is that with ψ1=0.7 and ψ2=0.3, investment in human capital has a greater impact on production compared to physical capital. This shows that any improvement in profit due to insurance is more significant when the investment is in physical capital.

Based on past research (Asa et al., 2021), we have taken the standard choices of ψ1=0.7 and ψ2=0.3. The final interesting observations are about comparing the RTB in the TP case and the Stackelberg game case. As observations showed, the RTB in the Stackelberg game is significantly higher in all cases. This may be due to the fact that the farmer leads in the Stackelberg game and can make decisions that bring the most profit for them.

Table 10- Total Relative Insurance Profit

				σ=0.1				σ=0.25			
				δ=3/7		δ= 7/3		δ= 3/7		δ= 7/3	
				α=0.9	α=0.95	α=0.9	α=0.95	α=0.9	α=0.95	α=0.9	α=0.95
Model 1	μ= 0.05	TP	VAR	0.365	0.504	0.151	0.238	0.703	0.825	0.434	0.532
			CVAR	0.41	0.582	0.294	0.381	0.791	0.851	0.620	0.699
		Stack	VAR	0.341	0.523	0.123	0.201	1.125	1.12	0.372	0.656
			CVAR	0.548	0.736	0.301	0.421	1.569	2.023	0.865	1.101
	μ= 0.1	TP	VAR	0.154	0.251	0.042	0.148	0.458	0.749	0.367	0.546
			CVAR	0.352	0.506	0.15	0.296	0.789	0.826	0.623	0.863
		Stack.	VAR	0.086	0.248	0.025	0.153	0.55	0.863	0.248	0.428
			CVAR	0.183	0.325	0.148	0.56	1.023	1.368	0.572	0.647
Model 2	μ= 0.05	TP	VAR	0	0.054	0.324	0.684	0.247	0.563	0.725	0.864
			CVAR	0.125	0.149	0.36	0.712	0.571	0.752	0.836	0.842
		Stack	VAR	0	0.018	0.368	0.451	0.222	0.521	1.102	1.54
			CVAR	0.054	0.158	0.502	0.712	0.56	0.905	1.624	2.023
	μ= 0.1	TP	VAR	0	0.001	0.165	0.324	0.124	0.541	0.635	0.715
			CVAR	0.054	0.082	0.324	0.574	0.41	0.748	0.847	0.825
		Stack	VAR	0	0.001	0.092	0.214	0.072	0.384	0.56	0.948
			CVAR	0.025	0.036	0.247	0.367	0.448	0.524	1.054	1.284

All the calibrations we have done have a very wide range of relative profit, and in many cases, it is significantly high. From Table 1, it can be seen that the RTB range is between 0 and 202 percent. Let us discuss the results for RTB in three cases:

Case 1: 1 > RTB > 0. This constitutes the majority of the results, and it is clear that relative insurance profit can be inferred.

Case 2: RTB > 1. The condition RTB > 1 only occurs for the Stackelberg approach with high volatility σ=0.25. For example, with the Stackelberg approach when δ=3/7, μ=0.05, and σ=0.25, RTB is 2.023.

RTB higher than 100 percent only occurs if $VN \leq VIN$. From RTB > 1, we understand that $VN<0<VIN$. This means that the problem of no insurance being practically feasible does not exist because its profit is always negative.

5. Conclusion and Recommendations

Conclusion

Introducing an insurance price index as a risk management tool has a positive impact on the supplier's value in maintaining stable income. Insurance is a map in which the risk of price fluctuations is shared between the supplier and the insurance company. In this work, we observed that by introducing insurance products, it is possible to achieve higher profits with less investment. Therefore, insurance can be considered to play an important role in addressing the agricultural sector, especially in developing countries that suffer from chronic underinvestment. Insurance can increase the value created by investment, which essentially means increasing the relative profit of investment. We observed that insurance can also have a positive impact on consumer welfare, and the optimal amount increases. Introducing insurance can enhance the impact of any early investment, which is a significant advantage for small and medium-sized agricultural companies that typically suffer from a lack of investment. This study shows that introducing insurance in the agricultural supply chain can encourage small and medium-sized companies to invest in agriculture. In this study, we reached the following conclusions:

First, it relates to the riskiness and risk-aversion of the farmer. High price risk always increases the value of insurance. Additionally, moving from VaR to CVaR indicates a higher relative profit from insurance for the farmer.

The second result relates to the curvature of the cost function. The second observation is about the curvature of the cost function. δ is a parameter that is considered. A higher δ indicates a higher curvature, which always has a lower relative profit. This study shows that the insurance price can play a key role in improving overall efficiency in the agricultural sector, especially in materials, and theoretically, introducing insurance can increase the effect of any early investment in the agricultural sector. The results show the relationship between policy and management, including potential new solutions for the government to protect the income of agricultural companies. These insights can help policymakers better understand the social benefits of food chain risk management and make more effective decisions about subsidy policy planning with better private sector involvement.

Recommendations

1) **Enhance Collaboration Among Stakeholders**: Given the high correlation between suppliers and investors, it is recommended to enhance collaboration and communication among all stakeholders in the agricultural supply chain. This can lead to more cohesive strategies and better pricing models.
2) **Optimize Insurance Premiums**: Insurance companies should consider optimizing their premium structures to make them more attractive to potential investors. This could involve offering flexible premium rates based on the risk profiles of different agricultural products.
3) **Invest in Technology and Data Analytics**: Utilizing advanced technology and data analytics can help in better understanding market trends and consumer behavior, leading to more accurate pricing models and improved decision-making.
4) **Educate and Train Stakeholders**: Providing education and training programs for stakeholders on the importance of insurance and its impact on investment can help in increasing awareness and participation.
5) **Regular Model Reviews and Updates**: Given the dynamic nature of the agricultural market, it is essential to regularly review and update the pricing models to ensure they remain relevant and effective.

By implementing these recommendations, stakeholders can work towards a more robust and efficient agricultural supply chain, ultimately encouraging greater investment and ensuring the sustainability of the sector.

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